

Research Article

Analysis of Misconceptions on the Factors that Affect the Reaction Rate

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This study aimed to analyze the misconceptions in the chemical concept of the factors that affect reaction rates through a qualitative descriptive method. The misconceptions experienced by students were examined through analyzing journals, books, and field experiences. Furthermore, research was carried out to obtain misconceptions that were often experienced by students and the sources of those misconceptions. There were 30 misconceptions about the factors that affect the reaction rate based on the literature. Based on the results of the study, there were three misconceptions experienced by 20 students from the total number of 21 students. The misconception that most students experienced was that when the concentration of reactants increases, a reaction will take longer because there will be much more particles to collide. In addition, the rate of the same reactions was compared at different temperatures, and then the reaction with the highest temperature was defined as the rate of reaction. The next misconception was that the temperature increase in an exothermic reaction can increase the forward rate and decrease the reverse rate because the equilibrium shifts to the right. Misconceptions were caused by information from the internet, teachers teaching in schools, textbooks used by students and the everyday life experiences of students.

Keywords: misconception, chemical concept, literature

1. INTRODUCTION

One of the chemical concepts that are considered difficult by students is the factors that affect the rate of reaction. Based on the results, found that 61% of students considered the concentration factor as a material that was difficult to understand in terms of the factors that affect the reaction rate. Difficult concepts are catalyst factor, temperature and surface area with percentages of 56%, 47% and 33%, respectively [1]. When students have difficulty in learning about a concept it can cause misconceptions. Misconceptions are concepts that contradict scientifically accepted theories [2].

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Constructivism learning methods, interpret new information using their previous knowledge. This situation emphasizes the importance of prior knowledge in the learning process. When students experience misconceptions in the previous concept, this misconception will be used as the basis for solving a problem. In this context, there is a consensus in the literature between chemistry educators and researchers that misconceptions should be defined and eliminated. Therefore, the analysis of misconceptions is an important research in chemistry education [3]. Factors that affect the rate of a reaction is one of the chemical concepts that are often studied by students. The concept is part of the rate of reaction or chemical kinetics. The ability of students to understand concepts, whether obtained through interaction with the environment or concepts obtained from formal education is called conception. Conception is the embodiment of people's interpretation of an object they observe which even appears before learning [4].

The incomplete understanding of students is caused by the misconceptions they bring when learning into the classroom. In general, the presentation of chemical concepts involves macroscopic and symbolic representations, while submicroscopic representations are ignored [5]. This will have an impact on the incomplete understanding of students. Incomplete understanding of chemical concepts can lead to conceptual errors. Conceptual error is the understanding of a concept that is not in accordance with the views of the scientific community and the wrong understanding is used consistently [6].

A thorough understanding of chemical concepts is obtained by connecting the three levels of chemical representation [5]. Three levels of chemical representation are macroscopic, submicroscopic, and symbolic levels. The macroscopic level displays obvious chemical changes such as color change, pH solution, gas formation and precipitate formation [7]. The submicroscopic level describes chemical changes using the smallest levels such as particles, atoms, molecules, ions, and electrons. The symbolic level involves formulas, pictures, structures, models and animations that explain the submicroscopic and macroscopic level [8]. Students' understanding at the sub-microscopic level for reaction rate was the lowest when compared to representations at other levels [9]. The symbolic level cannot be separated from the macroscopic and submicro level because this level is also represented and communicated by the symbolic (10). A central aspect of studying chemistry is learning to relate phenomena at a submicroscopic level and thereby being able to explain observable phenomena. This activity can support students' abilities in describing, interpreting and explaining chemical phenomena [11].

This study aims to obtain misconceptions on the concept of factors that affect the rate of reaction. This review was conducted by analyzing the scientific research literature

as well as students' experiences in learning that showed misconceptions. In addition, it also provides information about the source misconceptions.

2. RESEARCH METHOD

This study used a descriptive qualitative method. This study includes published research that addresses misconceptions about reaction rates, in particular the concept of factors affecting reaction rates. To identify relevant articles, a systematic search was conducted using the document analysis method. The process includes several stages, namely identifying 21 articles about misconceptions on the reaction rate followed by identifying the results of the misconceptions found on the factors that affect the reaction rate. After that, the misconceptions that were found were used as the basis for making instruments for data collection of student misconception in the field. This can be used to find out whether the misconceptions based on the article are also experienced by other students with different school backgrounds. The instrument used is a questionnaire consisting of 30 questions about misconceptions and the sources of misconceptions obtained by the students. Then an analysis of students' misconceptions was carried out based on the data obtained and the source of the misconceptions. This research was conducted on high school students of class XI who have studied the rate of reaction.

3. RESULT AND DISCUSSION

This section consists of two parts, namely the factors that affect the reaction rate and sources of misconception.

3.1. Misconceptions of Factors that Affect the Reaction Rate

This research was conducted in high school with the research subjects of high school students of class XI who have studied the rate of reaction. Based on the literature study, obtained as many as 30 misconceptions on the factors that affect the reaction rate as shown in Table 1. Based on the literature, the least common misconception is the surface area factor, while the most common is the temperature factor. The 30 misconceptions obtained from the literature were then used as questionnaire questions. The questionnaire was given to high school students in class XI who have studied the reaction rates. The number of respondents in this study were 21 students. The results obtained from students' answers regarding the misconceptions are as shown in Figure1.

The serial number of misconceptions in the diagram below corresponds to the sequence of misconceptions in Table 1.

Based on Figure 1, the most common misconceptions are 2, 24, 28, experienced by 20 students. Based on the misconceptions in Table 1 and Figure 1, it is found that there are three misconceptions that are often experienced by students from the 30 existing misconceptions. The three misconceptions are:

1. The concentration of reactants increases and reaction will take longer because there will be much more particles to collide.
2. If the rate of the same reactions are compared at different temperatures then the reaction with the highest temperature is defined as the rate of reaction.
3. The temperature increase in an exothermic reaction can increase the forward rate and decrease the reverse rate because the equilibrium shifts to the right.

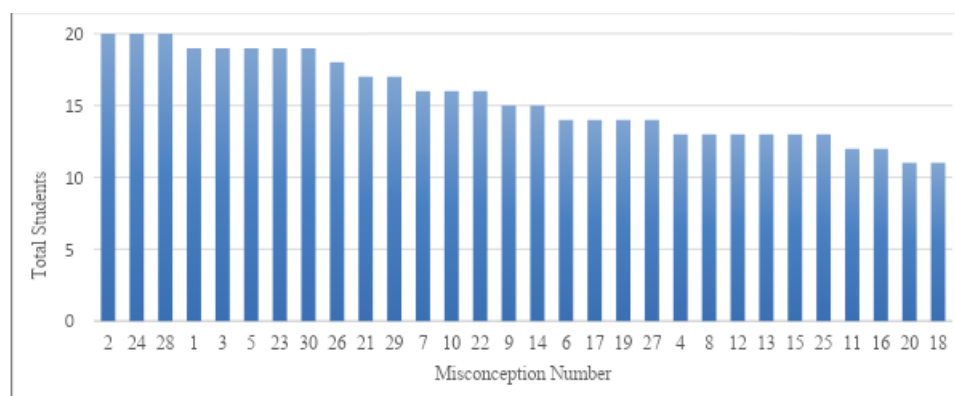


Figure 1: The most common misconceptions.

Students have difficulty in connecting the concept of the effect of concentration on the reaction rate with the collision theory and the concepts of exothermic and endothermic reactions in determining the reaction rate. Misconceptions in this concept which will later be used as the basis for solving problems in the next concept [3]. Therefore, it is important for teachers to know these misconceptions so that students are given a scientifically correct understanding of concepts. Understanding the correct concept can make it easier for students to learn the next concept correctly scientifically so that the student gains a complete understanding of a concept.

Based on Figure 2, the misconceptions experienced by students are caused by teachers, textbooks used by students, information sources from the internet, and students' daily experiences. The factors that cause misconceptions are daily life experiences, textbooks, teachers, and the language used [32]. Another researcher also said that

TABLE 1: Misconceptions of factors that affect the reaction rate.

Concept	Misconception
Effect of Concentration on Reaction Rate	If the concentration increases then the space for collision increases so the probability of a reaction increases [11].
	The concentration of reactants increases, the reaction takes longer because more particles collide [12, 13].
	The concentration of reactants increases, the rate of reaction will increase because the surface area of reactants increases [13].
	If the reactants are in solid or liquid phase, the rate of reaction decreases [14].
	Reaction rate depends on both the concentrations of reactants and the products [14].
	The concentration increases, the rate of the reaction remains constant because the number of collisions increases.
	Concentrations of reactants in a rate equation have exponents equal to the stoichiometric coefficients of the reactants in a balanced equation for the reaction [15].
	All orientation of collision could produce reaction [16, 17].
Effect of Surface Area on Reaction Rate	Substances with a smaller particle size will have a smaller surface area in the same mass [16, 18].
	If the surface area of reactants is small, the reaction will be faster, and if the surface area is large, the reaction will be slower [18–20].
	The mass of the reactants increases as the rate of the reaction increases because the surface area of the contact area increases [13].
Effect of Catalyst on Reaction Rate	The addition of a catalyst can increase the activation energy [18, 21, 22].
	Catalyst would increase the yield of the products [14, 15, 23].
	Activation energy is the amount of energy released by a reaction [23].
	The catalyst will not change the reaction mechanism, because it does not react with the reactants during the reaction [13, 23, 24].
	Fraction with high activity energy, the probability of collision decreases [25].
	Catalyst increases reaction rate by decreasing the kinetic energy of the molecules [14].
	Catalyst does not affect the reaction rate if reactants are in a liquid or solid state [14].
	To increase the rate of reaction, it is not necessary to increase the concentration of the catalyst since a small amount is adequate to change the energy profile of the reaction [26].
The presence of a catalyst in a reaction can form a variety of different products from the catalyst [25].	
Effect of Temperature on Reaction Rate	An increase in temperature causes the activation energy to increase so the reaction is faster [18, 27, 28].
	When the temperature increases, the rate of the exothermic reaction will decrease, but the rate of the endothermic reaction will increase [12, 23, 29].
	Exothermic reactions are faster than endothermic reactions [14, 25, 29, 30].

TABLE 2: Continued.

Concept	Misconception
	If the rate of the same reactions are compared at different temperatures then the reaction with the highest temperature is defined as the rate of reaction.[19].
	An increase in temperature can decrease the kinetic energy and increase the activation energy [14, 20, 22].
	The rate of reaction is doubled when temperature is raised by 10 °C because the change in rate depends only on the change in temperature [26].
	The rate constant of a reaction does not increase when a catalyst is used since its value is affected only by a change in temperature [31].
	For an exothermic reaction, an increase in temperature increases the rate of the forward reaction as well as decreases the rate of the reverse reaction since the equilibrium is shifted to the right. [31].
	As the temperature of a gas increases, the Boltzmann distribution curve for molecular speeds broadens and shifts to the right, while the height of the maximum point remains constant since the molecules have higher average energy while its total number remains constant [26].
	Reactions are generally faster at high temperature because the activation energy increases [28].

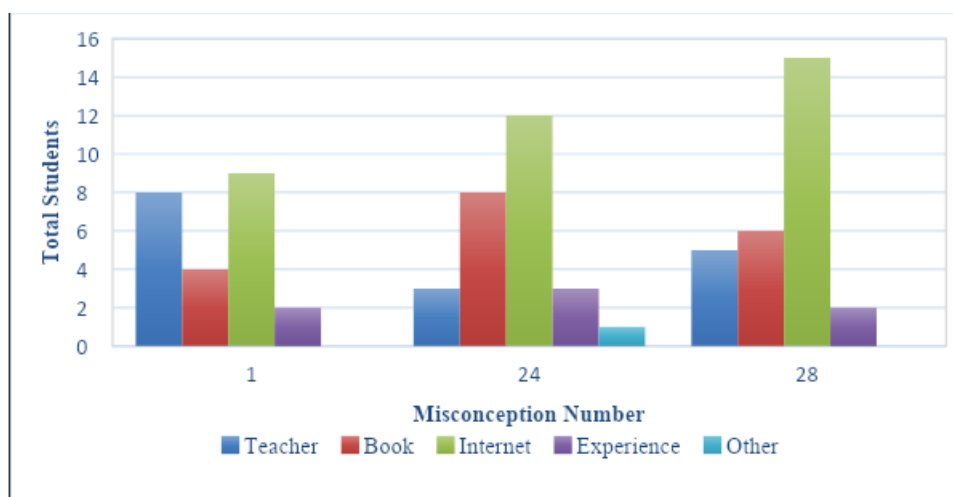


Figure 2: Source of misconception on factors that affect the reaction rate.

there are five things that cause misconceptions, namely teachers at school, teachers outside of school, daily experience, school environment, and intuition [33]. However, the basic thing that makes students misinterpret the concept of science is the characteristics of the concept itself such as abstract and complex [34].

The misconceptions that come from teachers in schools are caused by the concepts and methods used. Inappropriate teaching methods can be stopped by keeping teachers up-to-date in their subjects through further education [35]. Another important task is to make suggestions of learning strategies to improve lessons, which will lead to the preconception and misconception challenges that the school creates: recommending alternative strategies to traditional approaches, setting up laboratory experiments, using

more structural models or new technology-based methods [35]. Appropriate learning strategies can avoid misconceptions and build students' thorough understanding of chemical concepts.

Based on Figure 2, the most common source of misconceptions comes from the internet. Based on research, the use of the Internet in education shows that searching for information on the internet has become the first choice for many people, especially for students. The results of this study indicate that students use the internet to search for their homework and projects by using a search engine. However, research shows that students do not have sufficient skills and knowledge to search for information on the web [36] which ends up obtaining a large amount of irrelevant information about their studies. They don't pay attention to the information (e.g., source, date, and reliability) focusing on what it says. According to this conception, most students accept what they find on the Web as true, without considering the source or destination of the information. This brings up some important and interesting issues. This proves that students do not know how to use the internet, especially when looking for information on the web. Students do their homework or assignments with the "copy-paste" method without worrying about the reliability of internet sources. The misuse of the Internet by students can lead to erroneous learning and misconceptions.

The use of books for students is very important, because books are a source of learning. If students do not understand or forget the explanations given by the teacher, then students read the book again. However, books are often a source of misconceptions for students. The words or sentences contained in the book can interpret various views. If the misconceptions experienced by these students are not immediately addressed, they will become students' understanding forever. Before learning in class, students have different experiences. The experiences of these students can affect the next learning process. If students have the wrong experience on a concept then the student will have difficulty in explaining the next concept which causes misconceptions again.

4. CONCLUSION

In conclusion, the factors that affect the reaction rate are very important to understand because they will be used to study the next concept. However, when students have an understanding of concepts that are not in accordance with scientific concepts, it is called misconception. The most common misconceptions found in the concept of factors that affect the reaction rate are the concentration of reactants increases reaction will take longer because there will be much more particles to collide, if the rate of

the same reactions are compared at different temperatures then the reaction with the highest temperature is defined as the rate of reaction, and the temperature increase in an exothermic reaction can increase the forward rate and decrease the reverse rate because the equilibrium shifts to the right. This misconception can cause students to have learning difficulties. Sources of misconceptions are teachers at school, daily experiences, the internet and books used as learning resources. To avoid misconceptions, it is necessary to understand the concept thoroughly. Complete understanding of a concept is when students can integrate three levels of chemical representation (macroscopic, sub microscopic, and symbolic).

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